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RADIO FILTER OF COMBLINE STRUCTURE WITH CAPACITOR COMPENSATION CIRCUIT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a radio filter employing transmission lines, and more particularly a radio filter of combline structure with a capacitor compensation circuit connecting multiple filter layers through via-holes.

2. Description of the Related Art

It is generally desired to manufacture a portable radio communications system, like a mobile phone, being of small size and low cost. Of course, this applies to other kinds of equipment and therefore development of various technologies is required.

In order to reduce the size of the portable radio communications system having a radio filter for receiving or transmitting signals of a desired frequency band only, while blocking other noise signals, transmission lines (stripline or micro stripline) are used which occupy much less space than passive elements.

Such a strip-line filter is disclosed in U. S. Patent No. 4,963,843 granted to Motorola on October 16, 1990, in reference to which the conventional combline stripline filter is briefly described as follows:

The conventional combline stripline filter comprises a substrate having top and bottom surfaces each with a conductive material thereon forming a respective ground plane. The substrate also has an inner circuitry layer, which includes a ground area consisting of a conductive material having a plurality of angled edges, and coupled to at least one of the ground planes, and at least two combline resonators. Each resonator comprises a strip of conductive material. The strips are substantially parallel to one another. Each strip has adjacent first ends coupled to at least one of the ground planes, and adjacent second ends capacitively coupled to the ground area. Each of the adjacent second ends further has at least one angled edge disposed opposite a corresponding angled edge of the ground area. Each strip further has a respective extension portion at the second ends disposed substantially at right angles to the parallel strips. Each extension portion has a respective edge disposed opposite and capacitively coupled to the ground area. One of the extension portions is coupled to the radio signal.

However, such a conventional stripline filter employing the pattern capacitor as described above suffers from increased layout size and increased error of the pattern capacitor caused by electrical interference. In addition, it is hard to connect with other devices, and its capacitance cannot be accurately measured because of its being capacitively coupled to ground.

Furthermore, its manufacture is complicated because the type of material used for the substrate determines the capacitance with respect to the ground area. Moreover, since the connections with the input pads, output pads, and ground are made at the ends of the substrate, the sizes and positions of other devices connected thereto are very limited.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a radio filter of combline structure with a capacitor compensation circuit connecting multiple layers through via-holes.

It is another object of the present invention to provide a radio filter of combline structure with a capacitor compensation circuit employing the capacitor of lumped element as the capacitor compensator.

It is still another object of the present invention to provide a radio filter of combline structure with a capacitor compensation circuit, which can be embodied on an ordinary substrate.

According to the present invention, a radio-filter of combline structure with a capacitor compensation circuit, comprises a transmission line filter having at least a pair of transmission lines arranged between input and output terminals for filtering the input signals through the input terminal to select signals of a given frequency band delivered to the output terminal. Each of the transmission lines has a via-hole at each of its ends, a capacitor compensator of lumped element connected through one of the via-holes to one

of the transmission lines for providing capacitance between the transmission line and ground, and a ground layer connected to the other via-hole which is not connected to the transmission line in order to ground the transmission line.

The present invention will now be described more specifically with reference to the attached drawings which are shown for exemplary purposes only.

BRIEF DESCRIPTION OF THE ATTACHED DRAWINGS

Fig. 1 is a schematic diagram illustrating the structure of a stripline filter according to an embodiment of the present invention.

Fig. 2 is a view similar to Fig. 1 but with an additional pair of micro striplines arranged between the first pair of striplines of Fig. 1.

Fig. 3 is a partial exploded view for illustrating the inventive stripline filter arranged in an ordinary multi-layer substrate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, the inventive radio filter comprises a top filter layer 100 provided with a pair of micro striplines 108a, 108b forming the filter, and a bottom ground layer 120 supporting the top filter layer. Namely, the radio filter has the combline structure with the micro striplines 108a and 108b arranged on an ordinary copper clad laminate (CCL) substrate. The micro striplines 108a and 108b are coupled through via-holes 102a, 102b, 104a, and 104b to the bottom ground layer 120.

Namely, the micro striplines 108a and 108b are respectively coupled through the via-holes 102a and 102b to capacitor compensators 110a and 110b which are grounded, and also grounded through the via-holes 104a and 104b to the bottom ground layer 120. This is called a "blind via-hole arrangement".

Alternatively, the via-holes 102a and 102b are extended to the bottom ground layer 120 to connect with the capacitor compensators 110a and 110b, which is called "through via-hole arrangement".

In the present embodiment, the inventive radio filter is described in connection with the blind via-hole arrangement.

A first 108a of the pair of the micro striplines 108a and 108b constituting the radio filter is connected with the input terminal 106a, and the second 108b of the pair of the micro striplines is connected with the output terminal 106b. Each of the micro striplines 108a and 108b has via-holes 102a and 104a or 102b and 104b at respective ends. The via-holes 104a and 104b respectively connect the micro striplines 108a and 108b with the bottom ground layer 120, while the via-holes 102a and 102b respectively connect them with the capacitor compensators 110a and 110b.

The capacitor compensator 110a, 110b should have such a capacitance value that the length of the micro stripline 108a, 108b electrically meets the half wavelength of the center frequency of the radio filter. Thus capacitor compensators 110a and 110b reduce the length of the micro striplines 108a and 108b, and easily adjust the impedance matching and tuning. To this end, using a capacitor of lumped element, the capacitance is easily adjusted without

adjusting the width or distance as in the conventional filter arrangement.

Although the capacitor compensators 110a and 110b are shown in Fig. 1 respectively arranged at the ends of the micro striplines 108a and 108b, each on the same side, their positions may be varied. The capacitances of the capacitor compensators 110a and 110b should be determined considering the capacitances of the via-holes 102a and 102b. Of course, the capacitances of the via-holes 102a and 102b vary from the blind via-hole arrangement to the through via-hole arrangement.

The radio filter thus obtained filters the input signals from the input terminal 106a to only select the signals of a given frequency band which are delivered to the output terminal 106b. In this case, the given frequency band is determined by the length of and the space between the micro striplines 108a and 108b, and the capacitances of the capacitor compensators 110a and 110b connected through the via-holes 102a and 102b to them. Further, additional via-holes may be provided in the input and output terminals 106a and 106b in order to connect other devices with the radio filter. For example, an additional via-hole in the input terminal 106a may be used for connecting with an antenna, with others in the output terminal 106b for connecting with another signal processing device.

Referring to Fig. 2, a pair of additional micro striplines 208b and 208c are arranged between a pair of micro striplines 208a and 208d which are respectively connected with the input and output terminals 206a and 206b, as

shown in Fig. 1. Of course, the number of the micro striplines arranged between the outer micro striplines 208a and 208d may be increased.

Referring to another embodiment shown in Fig. 3, the radio filter of multi-layer structure includes an additional layer 340 which is placed over the filter layer 300, as compared to the previous embodiment. Namely, the filter layer 300 containing a radio filter consisting of the striplines 308a and 308b is interposed between the top and bottom ground layers 320 and 340.

The filter layer 300 comprises an ordinary CCL substrate upon which the striplines 308a and 308b are arranged to construct the radio filter. In addition, the striplines 308a and 308b are respectively provided with a plurality of via-holes 302a, 304a, 310a, 302b, 304b and 310b. Thus, the striplines 308a and 308b are respectively connected through the via-holes 304a and 304b to the bottom ground layer 320, and through the via-holes 302a, 302b, 310a, 310b to the top ground layer 340.

Namely, striplines 308a and 308b are respectively connected through via-holes 302a and 302b, and via-holes 348a and 348b to the capacitor compensators 350a and 350b which are grounded, and through via-holes 310a and 310b, and via-holes 344a and 344b to the striplines 342a and 342b. This is the blind via-hole arrangement because the capacitor compensators 350a and 350b and striplines 342a and 342b are not connected through the via-holes to the bottom ground layer 320. Of course, they may be designed to connect through via-holes with the bottom ground layer by using the through via-hole arrangement.

Describing more specifically the radio filter thus obtained, one 308a of the pair of the micro striplines 308a and 308b constituting the radio filter is connected with the input terminal 306a, and the other 308b of the pair of the micro striplines is connected with the output terminal 306b. Each of the micro striplines 308a and 308b has via-holes 302a and 304a or 302b and 304b at respective ends.

The respective via-holes 310a and 310b of the input and output terminals 306a and 306b are respectively connected with the via-holes 344a and 344b of the top ground layer 340. The via-holes 304a and 304b connect the respective striplines 308a and 308b with the bottom ground layer 320, while the via-holes 302a and 302b respectively connect them through the via-holes 348a and 348b of the top ground layer 340 to the capacitor compensators 350a and 350b.

The top ground layer 340 is provided with a pair of closed loop striplines 342a and 342b enclosing a given area corresponding to the striplines 308a and 308b of the filter layer 300. The areas of the closed loop striplines 342a and 342b are respectively provided with via-holes 344a and 344b connected to the via-holes 310a and 310b of the input and output terminals 306a and 306b which are connected with striplines 308a and 308b. The striplines 342a and 342b serve the input and output terminals of the radio filter.

An additional pair of closed loop striplines 346a and 346b are provided in the top ground layer 340 to connect with the via-holes 302a and 302b

formed at one-side ends of the striplines 308a and 308b of the filter layer 300. Namely, the areas enclosed by the closed loop striplines 346a and 346b are respectively provided with via-holes 348a and 348b connected to the via-holes 302a and 302b. In addition, the via-holes 302a and 302b are respectively connected with the capacitor compensators 350a and 350b.

The capacitor compensators 350a and 350b consist of capacitors of lumped element as described in the previous embodiment with capacitances proper for the frequency band filtered. Namely, the capacitor compensator 350a, 350b should have such a capacitance that the length of the micro stripline 308a, 308b electrically meets the half wavelength of the center frequency of the radio filter. The purpose of the capacitor compensators 350a and 350b is to reduce the length of the micro striplines 308a and 308b, and to easily adjust the impedance matching and tuning. To this end, using a capacitor of lumped element, the capacitance is easily adjusted without adjusting the width or distance as in the conventional filter arrangement. Although the capacitor compensators 350a and 350b are shown in Fig. 1 respectively arranged at the ends of the micro striplines 308a and 308b on the same side, their positions may be varied.

The capacitance values of the capacitor compensators 350a and 350b should be determined considering the capacitances of the via-holes 348a and 348b. Of course, the capacitances of the via-holes 308a and 308b vary from the blind via-hole arrangement to the through via-hole arrangement.

The radio filter thus obtained filters the input signals from the input stripline 342a through the via-holes 344a and 310a to the input terminal 306a to select the signals of a given frequency band only which is delivered to the output terminal 306b, which then transfers the signals through the via-hole 310b to the via-hole 344b of the top ground layer 340. In this case, the given frequency band is determined by the lengths of and the space between the striplines 308a and 308b, and the capacitance values of the capacitor compensators 110a and 110b connected through the via-holes 302a, 348a and 302b, 348b to them. Further, the striplines 342a and 342b provided in the top ground layer 340 may be used to connect other devices to the radio filter. For example, the stripline 342a may be used to connect an antenna, and the stripline 342b may be used to connect with another signal processing device.

Each layer of the inventive radio filter is composed of a CCL of epoxy resin, so that the conventional process may be used to construct the striplines. This facilitates the production of the radio filter with reduced cost.

Further, the capacitor compensates for the length of the stripline to electrically select the half wavelength of the center frequency of the radio filter. While the present invention has been described in connection with specific embodiments accompanied by the attached drawings, it will be readily appreciated that various changes and modifications may be made thereto without departing the gist of the present invention.